3D Printing for Mixed Reality Hands-On Museum Exhibit Interaction

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Figure 1: Functional implementation of MR with 3D printing for a new museum exhibition format

ABSTRACT

This work presents a combination of 3D printing with mixed reality to use the results in the context of museum exhibitions or for cultural heritage. While now priceless artefacts are encased in glass, kept safe and out of reach of the visitors, we present a new pipeline which would allow visitors hands-on interaction with realistic 3D printed replicas of the artefacts which are then digitally augmented to have the genuine artefacts' appearances.

CCS CONCEPTS

• **Computing methodologies → Mixed / augmented reality**.

KEYWORDS

cultural heritage, 3d printing, augmented reality, mixed reality

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1 INTRODUCTION

People are increasingly disinterested in visiting museums in person due to the accessibility of information online. To boost visitor numbers, museums are increasing use of technologies to attract audiences and at the same time enrich their displays [Chen and Lin 2018]. In some way the technologies which can be employed are similar to ones used for cultural heritage purposes, which employ methods from modern shape modeling, visualization and digital reconstruction. The Franklin Institute is an example of a museum already adopting AR technology through an app which visitors would download before attending [Hurdle 2017]. It used image recognition tracking to detect a brochure of terracotta warrior images, which can also be accessed online, and would display a 3D model of the corresponding warrior stood on top of the image.

In this work we present a pipeline which combines the growing technologies of Augmented Reality and 3D printing to create a new Mixed Reality museum exhibit format, that could bring a new level of interactivity to educative leisure at museums by educating through trending digital experiences rather than traditional methods. The resulting new format may encourage visitors to attend museums for a new opportunity to get hands on with 3D printed replicas of artefacts usually shielded behind glass, as they are too delicate or precious for handling by members of the public. These are accompanied by an AR application installed on a museum-owned device, removing the necessity for visitors to install software on their own devices, and instead requiring them to be present inside the museum. When held before the device's camera, the application recognizes and tracks the 3D printed replica, and visualizes a genuine-appearing digital version of the same artefact over it in the camera view to the effect that the visitor is interacting with a genuine artefact.

2 METHOD OVERVIEW

Our generalized pipeline achieves a digitally fabricated replica of an artefact, which when scanned by an application using augmented reality technology will take the appearance of the original artefact.

2.1 3D model acquisition

To translate an owned artefact into 3D, a museum can utilize a low-cost desktop 3D scanner, or a more accurate micro-CT scan.

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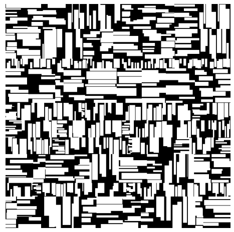

Figure 2: Texture image for tracking pattern.

Normally the scanned model requires further parameterization to ensure correct mapping of the tracking pattern on the next step. This parametrization can be done either automatically [Hormann et al. 2008] or manually.

2.2 Design tracking pattern

A successful pattern will be visually interesting with high contrast, allowing reliability of the application in detecting the replica. The pattern must not repeat anywhere on the model so the correct part of the digital artefact can be shown on the corresponding area of the physical replica. The tracking pattern we developed was inspired by barcodes and QR codes, as they have angular feature points with high contrast which can be reliably tracked; since they require only few feature points to be described and colors which contrast well in various lighting conditions (see figure 2). The randomly sized and spaced black quadrilaterals on a white background with a vast number of unique varieties are perfectly suited to this application.

2.3 Digital fabrication of the replica

The tracking pattern we use employs just two colors which allows the fabrication of the model on a wide range of low-cost dual-extruder 3D printers. The majority of these machines require a separate volume of each color. To efficiently do that in our method we extrude the meshes' faces inward to reform manifold polygonal meshes for each material. Also we would like to note that for the best results the materials for 3D printing should be as contrasting as possible to ensure proper tracking of the resulting replica object in the AR application.

2.4 Data capture and display

To create the tracking data, images of the digitally fabricated replica should be captured from all angles and against a plain background. The AR tracking system used should allow the conversion of image samples into a point cloud to search for and track, which can be incorporated in the app development stage. Sample the lighting setup at the site of exhibition if you wish to match it for visualization.

The final step is to design and create the application which will implement the augmented reality integration. Load in an AR toolkit, the digital artefact model with textures and tracking data. Ensure the digital artefact will align accurately with the physical replica by setting the default transform in advance. Match the lighting and implement any dynamic elements if desired for added augmentation.

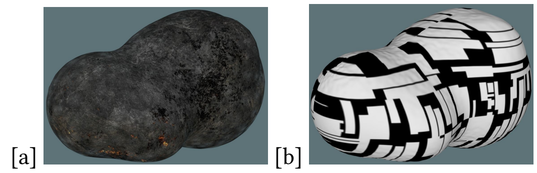

Figure 3: a) The meteoroid model as it is seen in the application, b) 3D model with tracking pattern;

3 RESULTS

Our implementation is built using the Wikitude SDK which brings AR capabilities into Unity. Maya was used for working on the models, Substance Designer for pattern development, 3D model slicing was completed using Ultimaker Cura and the print done on an Ultimaker 3. Since the result involves interacting with a physical object for digital feedback, the exhibition format uses Mixed Reality.

We tested our pipeline on a meteoroid model (see figure 3), which was selected as it is a plausible example of an artefact perhaps too fragile or rare to risk being handled by members of the public. The source model was manually retopologized both to attain printable quad geometry and to increase surface detail to a believable level through subdivision and displacement mapping. To accurately represent the fine details in shape and texture, a combination of white CPE and black nylon was used and produced the most successful 3D prints during our testing. Having a 3D printed replica of the meteoroid artefact printed as the tracking pattern allows it to be recognised by the MR app in real time, with the user able to see the textured digital model of the real artefact on the screen (see figure 1).

4 CONCLUSIONS AND DISCUSSION

This work presented a pipeline which connects Augmented and Mixed reality, 3D printing and Cultural Heritage where the results can be applied within museums to attract visitors and enrich their exhibitions. The proposed pipeline is a first step into bringing technology of mixed reality into modern exhibitions with considerable potential for further developments. For example, the artefacts can be shown as they exist today, or as they did before weathering, damages or the ageing process. Dynamic animations and effects could also be added, such as the glow, smoke and debris from a meteorite as it enters the atmosphere, not achievable with the digitally fabricated replica alone. Further, there is scope for incorporating a narrative between how the user interacts with the replica and what is displayed on screen. The pipeline thus far only addresses the visual component to the effect of handling a genuine artefact. In future work other properties including weight and surface texture of artefacts could be replicated and embedded into the replica.

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